The Impact of Great Lakes Ice and the Lake Ice Remote Sensing from Space

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The Laurentian Great Lakes with its vast natural resource contribute significantly to economic and social activities of North America. Therefore, the Great Lakes have long been central to many scientific studies from paleoclimatology to the present day climate problem, biogeochemistry, ecological stability, and environmental management and protection. Ice cover in the Great Lakes, the most obvious seasonal transformation in the physical characteristics of the lakes, has a major impact on the regional climate, local commerce, and public safety. Extending the winter navigation season can save millions of dollars in coal and ore shipping. To the hydropower industry, ice is potentially harmful to the installations on the Niagara River. The number of days that ice cover exceeds 40% is an important input parameter to a whitefish recruitment forecast model in Lake Michigan. Ice cover duration is predicted by several General Circulation Models to reduce significantly under the CO_2 doubling scenario. Winter ecology may be strongly affected by the ice cover reduction. Ice jams not only impede navigation but also cause dangerous flooding. These practical problems necessitate the remote sensing of the Great Lakes ice cover from space.

In the world's largest freshwater surface covering an enormous area of 245,000 km^2 with a drainage basin extending 1110 km northern-southern and 1390 km east-west, the Great Lakes ice cover is inherently a large-scale problem. On the other hand, many practical applications such as winter navigation, shore structure protection, and ice control require high resolution ice mapping. The Great Lakes ice cover sensing on the operational level demands near real time data, day and night operations, the minimization of atmospheric effects, and the capability to see through clouds. Owing to the size and extent of the Great Lakes and the variety of ice types and features found there, the timely and objective qualities inherent in computer processing of satellite data make it well suited for such studies. Much of the satellite ice interpretation algorithm development in the Great Lakes region began during the Extension to the Navigation Season Demonstration Study conducted during the 1970's. Investigations by various researchers were conducted to classify and categorize ice types and features, to map ice distribution, and to monitor and attempt to forecast ice movement with remotely sensed data. However, many of the early studies were done by visual interpretation of satellite and other remotely sensed data. Starting in the mid-1970's, a series of studies including field studies and computer digital image processing, explored techniques and algorithms to classify and map Great Lakes ice cover using Landsat, NOAA/AVHRR, and ERS-1 SAR data. The goal of much of this work is to develop an automated or semi-automated method to classify and map Great Lakes ice cover using satellite digital imagery. Future work will focus on developing freshwater ice analysis and interpretation algorithms using RADARSAT SAR data.